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Resilience of Desert Cities: Between Reality and Ambition

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ABSTRACT

This article aims to explore the characteristics of resilient city systems, which play a key role in urban and spatial planning. It also aims to create desert cities that achieve sustainable development goals and are able to withstand dynamic changes, as well as current and unforeseen challenges and crises. The Resilient City Framework tool was applied to the city of Najaf. This tool assessed the city's resilience based on principles such as quality of life, health, society and economy, infrastructure and ecosystems, strategic leadership, and governance. The results demonstrated the tool's success in assessing the city's resilience characteristics across all sectors. Furthermore, the findings revealed that resilience assessment tools are an effective approach for decision-makers and policymakers to develop strategies and mechanisms for sustainable development in response to challenges and dynamic changes.

1. INTRODUCTION

The rapid urbanization across the world and the concentration of populations in cities has become a defining characteristic of contemporary development. Statistics indicate that more than half of the world's population currently resides in cities. Urban growth has increased from 23.8% in 1950 to 50% in 2010, and is projected to rise to 70% by 2050. This rapid urban expansion, however, has made cities less resilient and more vulnerable to significant economic and human losses during crises [1].

As a result, there has been an increasing need for the concept of resilience, alongside a growing interest in desert cities. Studies have shown that resilient cities are better equipped to confront disasters and challenges, and they can recover more swiftly to their normal state after being affected by such changes and crises [2].

The resilience and ability of desert cities to withstand risks, shocks, crises, and unexpected changes are largely determined by urban planning—not only for residential areas but for the entire city. The process of planning a resilient city requires the adoption and activation of specific planning policies or the reformulation of existing ones to align with the current context, ensuring the city's objectives are met [3].

This can be achieved by identifying rational decisions and policies that result in appropriate and integrated solutions, consistent with the environmental and societal requirements of the city [4]. In order to catch up with the evolving research in the domain of resilient and sustainable cities, the literature review was revised to include emerging research published between 2020 and 2024. These works explore current trends in resilience assessment frameworks, climate adaptation strategies, and resilience-based urban governance. For example, Admiraal and Cornaro [5] stressed the role of underground infrastructure as a means to attain urban resilience, further recent works, including Sharifi and Yamagata [6] on comparative resilience indicators, which included climate-responsive planning in arid environments—were also addressed there. The updated version of the theory will ensure that the theoretical framework of the research is representative of the latest international research and strengthens the validity and relevance of its conclusions [5-7].

1.1 Concept of resilience

The concept of resilience was introduced into the English language in the 17th century, derived from the Latin verb "Resilio", meaning "to rebound" or "to recover" (Urban Centre). In terms of the Arabic translation, the word "resilient" has several synonyms, including returnability, flexibility, resilience and pliability, among others. Therefore, this concept is considered one of the modern terms that have emerged in research and writings across various fields, such as ecology, psychology, physics and urban planning [8]. It gained particular prominence following a series of crises and challenges, such as natural disasters, terrorist incidents and the recent economic recession that has affected numerous cities and communities. These concepts will be briefly addressed to arrive at a general definition of urban resilience [9].

1. Collins Dictionary defines resilience as the ability to adapt and recover when faced with change or misfortune.
2. Merriam-Webster Dictionary describes resilience as

something strong that can recover easily when exposed to pressures or injuries, meaning it is resistant to damage when harmful events occur.

3. Cambridge Dictionary defines resilience as the ability to quickly return to a normal shape after being pressed, stretched or bent.

1.2 Concept of the resilient city

After understanding the concept of resilience through various definitions in literature, we now turn to the concept of urban resilience. Urban resilience is a model that helps cities increase their capacity to adapt and confront the risks they face. In 2010, the concept of urban resilience was incorporated into urban planning and design due to negative environmental changes, especially in relation to climate change, natural disasters, political shifts, famines, wars and energy scarcity [10].

The concept of resilience has evolved through several stages, culminating in the emergence of urban resilience. These stages are outlined briefly below:

1.First Stage – 1973:

The concept first appeared in ecological literature, focusing on how systems adapt to the environment. It was defined as the fundamental ability of ecosystems to maintain desired services in the face of human exploitation and environmental changes [11].

2.Second Stage – 2001:

By 2001, the concept expanded to include both ecological and social aspects. Resilience was then defined as the capacity of social systems to adapt to and align with ecosystems to mitigate disturbances and maintain essential processes in the same year, the term urban resilience emerged, defined as a city's ability to absorb disturbances while maintaining its essential services, infrastructure and functions.

3.Third Stage – 2003:

The concept of the resilient city became explicitly linked to sustainability. International organizations and institutions agreed that resilience refers to the ability of communities, individuals, institutions and city systems to adapt and endure regardless of the type of disaster, stress or acute crisis a city may face. This definition includes all dimensions—environmental, economic and social—and was confirmed by the United Nations Human Settlements Programme.

Definitions of Resilient Cities

- OECD Definition:

A resilient city is one that can absorb future shocks and prepare for them across environmental, economic, social and institutional dimensions [12].

- UN-Habitat Definition:

A resilient city is one that can evaluate, plan and strive to prepare for and respond to all risks, whether expected or unexpected, sudden or gradual. In other words, it is a city capable of protecting lives, securing development gains, enhancing the investment environment, and driving positive change [13].

- 100 Resilient Cities Initiative Definition:

A resilient city is characterized by the capacity of its institutions, individuals, communities, and systems to survive, adapt and grow despite acute pressures and chronic challenges [14].

From these definitions, we can summarize that a resilient city, from a planning perspective, is one that encompasses multiple disciplines, as illustrated in Figure 1.

Figure 1. Depicts the structure of a resilient city

1.3 Foundations for achieving a resilient city

There are several essential foundations that must be established to create resilient cities capable of confronting challenges, difficulties, crises, and effectively dealing with them. Resilience needs to be achieved across several domains, including the environmental, social, political, urban, institutional and economic sectors [15]. This is in line with the recommendations of the Third United Nations Conference on Disaster Risk Reduction, which highlighted a set of pillars that support cities in becoming resilient and capable of facing various challenges.

The United Nations, in its projects, outlined ten key principles and pillars that have been adopted across all studies and initiatives aimed at achieving resilience [16], Governments participating in these projects are also required to adhere to these ten pillars to tackle difficulties and disasters effectively, by focusing on the following:

1. High-level coordination.
2. Clearly defined responsibilities.
3. Participation of all relevant stakeholders with well-defined roles.
4. Development of effective plans, policies and strategies, along with efficient communication systems and mechanisms for managing risks effectively.

Refer to Figure 2, which illustrates the ten pillars developed in parallel with the five priorities of the Hugo Framework 2015. This framework encourages and supports communities in enhancing their resilience to risks. It emphasizes understanding disaster risks, strengthening risk management to improve preparedness and response, investing in risk reduction to enhance resilience, and improving recovery efforts to rebuild better in terms of rehabilitation and reconstruction [17].

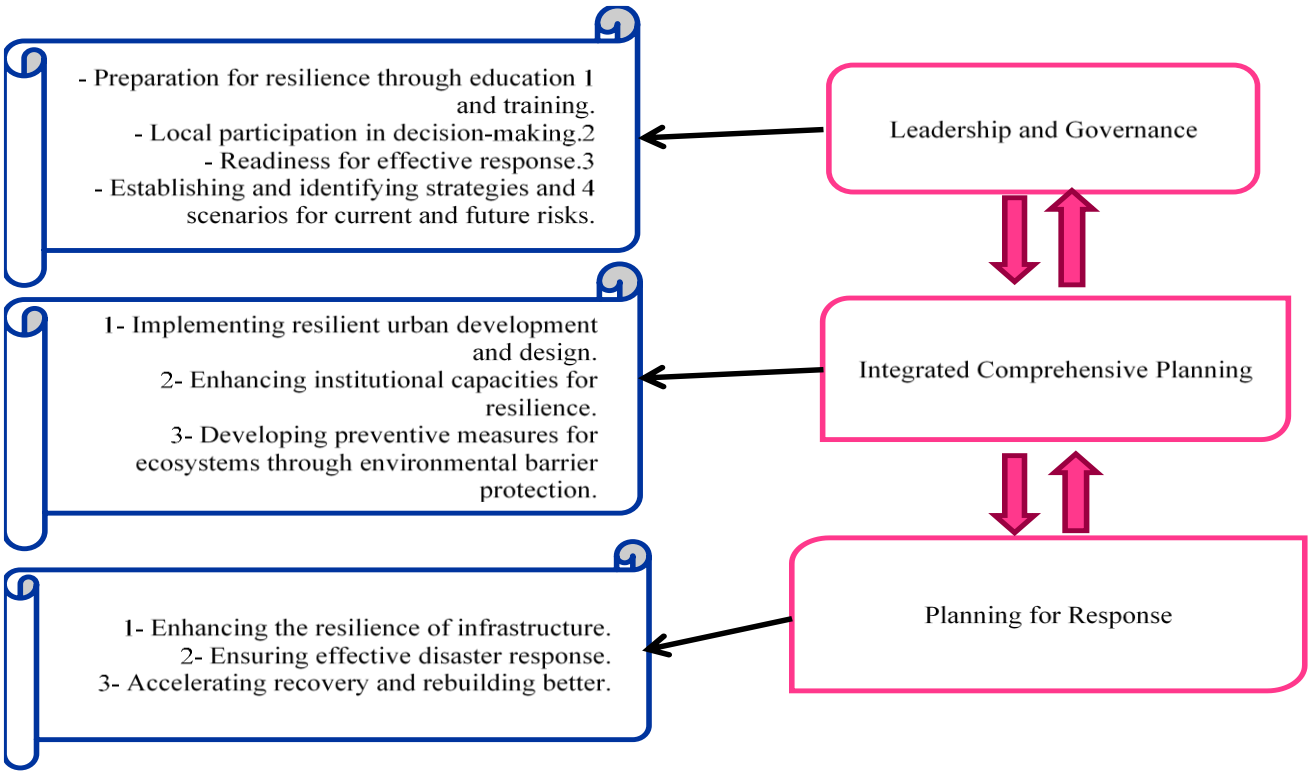

Figure 2. The ten pillars for empowering cities to enhance their resilience

1.4 Methods used to assess urban resilience globally

Many countries worldwide have adopted the ten principles of resilience to confront the crises, challenges and threats facing their cities. This has been achieved through the application of various tools and methods to assess resilience. Over fifty global methods and tools have emerged that enable cities to achieve and evaluate resilience. These methods and tools vary as the concept of resilience has evolved, particularly in how they address the foundational principles and pillars of resilience.

We will discuss some key models and important topics addressed by some of these global tools in chronological order:

- USIOTWT Tool (U.S. Indian Ocean Tsunami Warning System Program): Established in 2007 by the U.S. Agency for International Development, this tool encompasses pillars that achieve urban resilience in governance, economy, society, land use, structural design, coastal resource management, risk analysis, emergency plans, response plans, evacuation plans and crisis and disaster recovery plans [18].

- PEOPLES Tool: Introduced in 2010 by the National Institute of Standards & Technology, this tool has been implemented in the U.S. (We stem New York). It includes the following pillars: ecosystem, government services, population and demographics, economic, social and cultural development, physical infrastructure and community lifestyle and efficiency [19].

- ICBBR Tool: Released in 2012 by Canadian Red in collaboration with the Palang Merah Indonesia Centre, this tool was applied to coastal cities in Indonesia, focusing on key pillars such as economy, knowledge, natural resources, infrastructure, health and social aspects.

- LDRI Tool (Localized Disaster Resilience Index):

Emerged in 2013, this tool focuses on essential pillars for achieving urban resilience, including human health and well-being, environmental resource management, sustainable livelihoods, economic and social protection and planning [20].

- RELI Tool: Introduced in 2015 by the American National Standards Institute, this tool centers on key pillars of preparedness for economic, productive and social risks, design and planning, water, food, innovation and resources. It has been implemented in the United States [21].

- COBRA Tool (Community Based Resilience Analysis): Developed by the Dry Lands Development Centre in 2015, this tool was applied in some African countries, including Uganda, Ethiopia, and Kenya, to assess the resilience of African communities. Its core pillars focus on society, resources and environment, infrastructure and economy [22].

- CRF Tool (City Resilience Framework): Implemented in 2016 by The Rockefeller Foundation, its core pillars for achieving urban resilience include leadership and strategy, ecosystems and infrastructure, society and economy and quality of life. An annual competition is held to select the best resilient city. This tool will be used in the research.

From the analysis of the aforementioned tools, it is evident that all the key pillars and foundations revolve around major sectors, specifically urban infrastructure, the environment, the economy and social aspects. Therefore, a city can be considered resilient if it achieves sustainability across these sectors.

1.5 Characteristics of resilient cities

Through the study of the foundations for achieving resilient cities and the various global assessment tools used to measure urban resilience, we can identify the essential systems that distinguish resilient cities from those that collapse under difficulties and adversities. These systems can be categorized into four dimensions: public welfare and quality of life, good governance and leadership, social and economic factors, and infrastructure and the environment. At the same time, resilient cities must exhibit several key traits, including:

1. Reflectiveness: The ability to benefit from past experiences and learn from history when making decisions to confront crises.

2. Inclusiveness: A comprehensive and shared vision is essential for a city to be inclusive. This requires inclusive processes built on extensive consultations among all stakeholders at various levels to foster a sense of shared ownership.

3. Diversity of Alternatives and Resourcefulness: The ability to generate solutions and identify alternative methods of utilizing available resources during crises to meet essential needs.

4. Integration: Resilient cities are characterized by integrated plans capable of addressing multiple issues, such as disaster reduction and effective coordination during emergencies through collaboration among systems and institutions to achieve desired objectives and reach greater goals [23].

5. Strength and Safety: Resilient cities possess robust infrastructure capable of overcoming obstacles and challenges, along with a solid design and security measures.

6. Flexibility: They adopt alternative strategies that are flexible in response to changes or sudden crises by utilizing modern technologies and advanced techniques.

1.6 Concept of desert cities

When discussing desert cities, many people tend to think of cities and deserts as two opposing concepts. The notion of a city refers to existence, urbanization and stability, while the idea of a desert signifies desolation, poverty and emptiness. Consequently, the term "desert city" is a composite of two essential concepts: "city" and "desert." In its simplest definition, a city is an urban settlement of a certain population size that fulfils administrative, economic, social and cultural functions, possessing characteristics that distinguish it from other cities. In contrast, the term "desert" refers to the geographical space of a desert region.

1.7 Characteristics of new desert cities

New desert cities today are marked by a failure in their urban planning to achieve harmony and adaptability to their environment, in contrast to traditional desert cities. As a result, they have become unable to withstand disasters and crises due to the following reasons [24]:

- Inefficient Social Services and Urban Structures: The urban infrastructure fails to meet the needs of the population and attract new investments.
- Poor Housing Design: The design of residential buildings exposes them to dust storms and sand dunes.
- High Solar Radiation: Large open spaces and streets are excessively exposed to solar radiation, hindering movement, especially during the daytime.
- Lack of Privacy: Residents' homes are open to the outside world, leading to security issues, particularly theft.
- Absence of Clear Energy Conservation Policies: This is a common issue in the construction of homes and buildings, where their exterior walls are subjected to direct sunlight throughout the day. This results in increased use of air conditioning systems, contributing to environmental harm.
- Complex and Rapid Changes: Desert cities continuously face complex and rapid changes, grappling with issues related to water, environmental challenges, future economic dynamics and social concerns. All these factors place pressure on these cities and their development processes.

2. PRACTICAL ASPECT

When it comes to applying resilience assessment tools in cities, the outcomes vary according to the unique conditions and underlying challenges of each city. In this case, the city of Najaf has been chosen for our research. It is crucial to identify the most suitable tool, considering the severity of its situation as a desert city. Thus, the aim of our modest research is to highlight the pressing issues faced by Najaf and determine the most effective resilience tool to address them. The CRF tool has been selected for this study for two reasons: first, because it encompasses all principles of resilience assessment; and second, due to its successful application in developing countries. This tool was updated in 2016.

2.1 City of Najaf

The city of Najaf (the study area) was established in a region characterized by its sacred nature and cultural significance, which grants it a unique advantage due to its proximity to the ancient civilizations of the Middle Euphrates, such as Babylon, Akkad and Sumer. It is also distinguished by its elevation compared to its surroundings, which historically provided protection against floods. Geographically, Najaf is located at a longitude of 44°19′ East and a latitude of 31°59′ North [25]. It is one of the prominent cities in Iraq, situated in the southwest of the country, and serves as the center of Najaf Governorate.

Najaf lies at the eastern edge of the Western Plateau, which separates Iraq from the borders of Saudi Arabia. It is bordered to the west by the Western Plateau and the Najaf Sea, to the south by Abu Sakhir and the town of Al-Hira, and to the north by the Najaf Plateau, while the city of Kufa is to the east, as shown in Figure 3. Given its geographical location, Najaf represents a transitional gateway between the alluvial plain and the Western Plateau, forming the middle and southern surface, with the Najaf Sea serving as the dividing line between them. This position places it in a desert climate characterized by winter conditions limited to the cold seasons, while summer temperatures can exceed 50 degrees Celsius on some days.

According to the latest statistics from 2017, its population is approximately 791,000 (Najaf Governorate Statistics Office), while the area of arable land is estimated at around 300,000 donums [26, 27]. The actual cultivated area is about 154,958 donums. This city has been known for its extensive trade in goods between the plain and the desert throughout its history. In terms of services, it is reported that there are 200 archaeological sites within the boundaries of this city (Najaf Archaeology Directorate), distributed among monasteries, Christian cemeteries and the Wadi Al-Salam cemetery for Muslims, which is considered one of the largest and oldest cemeteries in the world. Additionally, there are religious schools, heritage houses, historical buildings and mosques. The city is notably recognized for the sacred shrine of Imam Ali ibn Abi Talib (peace be upon him). Natural landmarks include the ancient Najaf plain, which has existed for over four thousand years, as well as the Najaf Sea. Furthermore, Najaf was chosen to be the Capital of Culture in 2012 [28, 29].

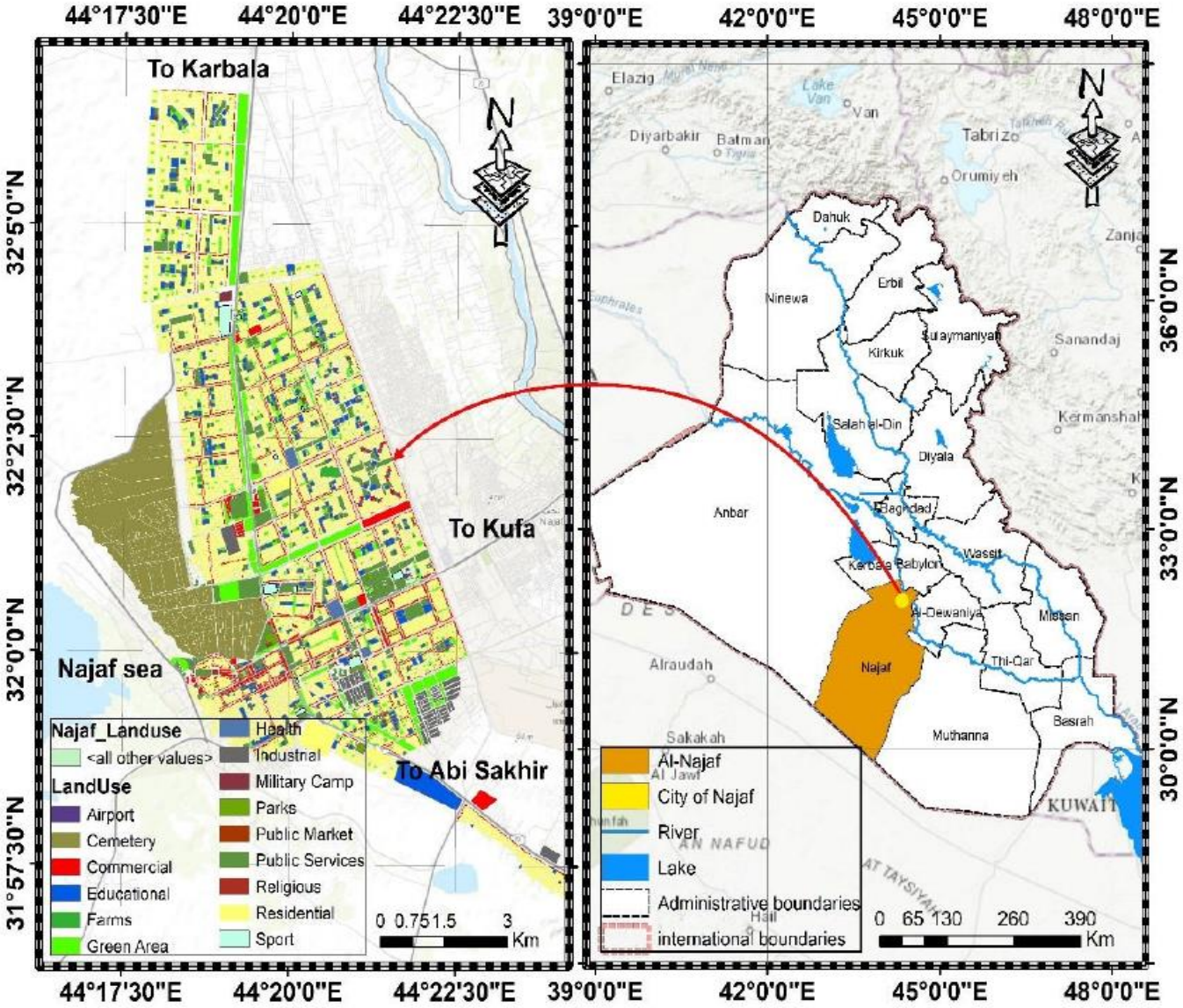

Figure 3. City of Najaf [28]

2.2 Assessment of the resilience of Najaf City using the CRF tool

As previously mentioned, the reason for selecting this tool is that it contains 150 indicators; however, our research will focus on 52 indicators. These indicators are organized into four main principles: Social and Economic, Quality of Life and Health, Ecosystems and Infrastructure and Strategic Leadership and Governance (Figure 4). Each main objective includes three secondary objectives, and each secondary objective has several sub-objectives, as illustrated in Table 1.

A total of 100 questionnaires Respondents were asked to rate the questions using the following scale: (0 = None, 1 = Very Weak, 2 = Weak, 3 = Average, 4 = Good, 5 = Very Good). The research then converted these values into weights ranging from (0, 1, 2, 3, 4, 5) and calculated the average scores for these indicators, as shown in Tables 2, 3, 4.

To secure robustness in the collection, the number of 100 questionnaires was determined in relation to the size of the professional community involved in urban planning and local governance in Najaf. Respondents were from the University of Kufa (Departments of Urban and Regional Planning), the Urban Planning Directorate, and members of local councils — institutions who have the greatest level of awareness regarding the city's state of resilience. This purposive sampling was designed to capture expert and institutional perspectives as opposed to general public perceptions, which justifies the relatively limited but highly specialized sample size. The questionnaire recovery rate was 87% and reliability was also performed with Cronbach's Alpha value of 0.84, verifying a high internal consistency between the responses. Taken together, these measures validate the adequacy of selection of the sample to reflect institutional perspectives on urban resilience in the city of Najaf.

To enhance the analytical depth of the study, additional statistical examinations were conducted to reveal relationships among the main resilience principles and their sub-indicators. A Pearson correlation analysis was applied to determine the strength and direction of associations between the four primary resilience dimensions—Quality of Life and Health, Economy and Society, Infrastructure and Ecosystems, and Strategic Leadership and Governance. The results showed a strong positive correlation between governance and infrastructure ($r = 0.76$), indicating that effective institutional coordination significantly enhances service efficiency and crisis preparedness.

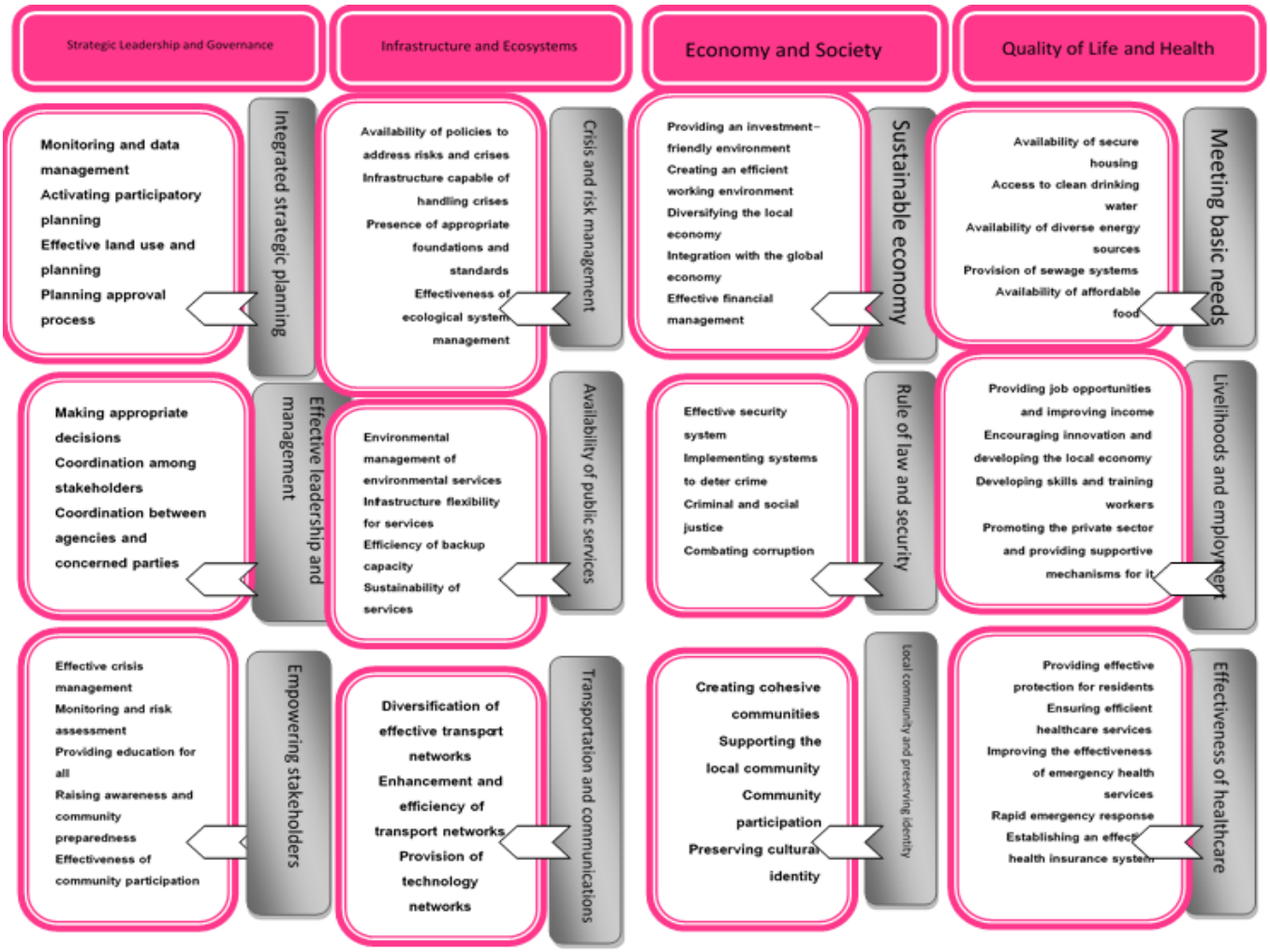

Figure 4. The main objectives of the resilience principles for the CRF tool

Table 1. Evaluation and measurement of the principle of Quality of Life and Health according to the CRF tool

Score	Value	Indicators	Sub-Goals	Secondary Objectives	Principle of Resilience
2	Weak	- Availability of safe housing at an affordable price.	Secure housing	Meeting basic needs	Health and Quality of Life
2	23%	- Percentage of families living in informal housing.			
2	%20	- Percentage of structurally damaged buildings.			
3	60%	- Percentage of income spent on rent.			
2	21%	- Percentage of unplanned areas.			
2	Weak	- Availability of plans for alternative water sources.	Availability of clean drinking water		
5	99%	- Percentage of the population connected to water networks.			
5	98%	- Percentage of the population connected to the electricity grid.	Availability of energy sources		
1	Very Weak	- Availability of alternative energy source plans, such as solar power.			
5	98%	- Percentage of the population connected to sewage systems.	Availability of sewage systems		
3	Average	- Availability of an emergency plan in case of malfunction.			
5	Very good	- Availability of sufficient food at reasonable prices.	Availability of food for residents		
4	Good	- Proximity of markets to residential areas.			
3	Average	- Availability of laws on the minimum working age.	Income policies and labour laws	Livelihoods and Employment	
2	Weak	- Value of daily wages.			
2	Weak	- Unemployment rate in the city.	Support for local economy		
1	10%	- Percentage of families below the poverty line.			
1	35%	- Percentage of families at average poverty levels.			
2	Weak	- Availability of youth education programmes.	Training and skill development		
2	Weak	- Availability of mechanisms to develop the labour market.			
2	Weak	- Provision of supporting mechanisms for the economy.			
2	Weak	- Availability of loans for young people.	Mechanisms for financial support		
0	None	- Availability of financial support for the private sector during crises.			
1	2%	- Percentage of female contribution in the private sector.			

4	Good	- Availability of educational programmes for healthcare awareness.	Provision of healthcare	Effectiveness of Healthcare
5	Very good	- Availability of doctors in hospitals.		
4	Good	- Speed of response in emergencies.	Efficiency of emergency healthcare	
4	Good	- Percentage of medical staff responding to emergencies.		
4	Good	- Availability of sufficient hospital beds during crises.	Rapid emergency response	
4	Good	- Availability of sufficient medical supplies and equipment.		
5	Very good	- Percentage of children who have received vaccinations.	Availability of health insurance systems	
2	Weak	- Availability of health insurance for the population.		
1	Very Weak	- Availability of health centres for elderly care.		
2	Weak	- Availability of plans to protect residents during crises.	Protection of residents after crises	
2	Weak	- Awareness among residents on how to deal with crises.		

First: Evaluating and Measuring the Principle of Quality of Life and Health:

In this section, the resilience of the city of Najaf will be evaluated and measured according to the principle of health and quality of life using the CRF application, as illustrated in Table 1.

From Table 1, when evaluating and measuring the indicators of Quality of Life for the city of Najaf, we observe that the primary objective of meeting basic needs ranks first with a percentage of 46%, followed by the goal of effective healthcare at 35%, and then the goal of livelihoods at 19%. Analysing these percentages reveals several weaknesses:

- There is a deficiency in the availability of housing units at affordable prices, and a segment of the population is deprived of adequate housing and social security in terms of building materials and social safety.
- There are no plans to prevent or address issues such as electricity and water outages and sewage network problems, which can lead to a crisis in the city and suffering for its residents.
- There is a lack of policies and programs for education and skill development, especially for the youth, as well as no mechanisms to support the private sector in stimulating the local economy during peacetime and in crises.
- Despite the relatively low percentage of families living below the poverty line, there is no support for these families from the government, nor is there a support fund for this demographic.
- There is no effective health insurance to protect residents in times of crisis.
- The participation of women in the private labour market is low, at only 20% according to international standards.
- There are no effective plans and policies to protect the population during crises, and this lack of preparedness extends to the public's awareness of how to deal with crises.

Despite these weaknesses, there are strengths in the evaluation and measurement of the indicators, including:

- Availability of food supplies for all demographics at reasonable prices, with markets located near residential units.
- The provision of essential infrastructure services such as clean drinking water, sewage networks and electricity for all residents of the city.
- Competent medical personnel are available to address health issues, and the capacity of hospitals is sufficient to accommodate patients, along with a good supply of medical necessities.

There is awareness among the population regarding the importance of basic vaccinations for children (Figure 5).

The chosen 52 indicators comprising the original 150 indicators based on the City Resilience Framework (CRF) were identified in a multi-stage process to allow for the inclusion of validated indicators for assessing the resilience of desert cities. In the first phase, indicators irrelevant to the environmental and socio-economic characteristics of arid areas—e.g., those that relate to coastal, flood and forest resilience—were dropped. In the two final stages of the project, a panel of six academic and professional experts in urban and regional planning assessed those remaining indicators following a relevance scoring approach according to three criteria: (1) the environmental compatibility with desert conditions; (2) the data availability in the local context; and (3) the fit to urban policy priorities in Najaf. The third stage consisted of a pilot test to verify the clarity and measurability of each indicator in the context of the city's institutional framework. To generate weighting, these responses produced on the questionnaire were converted to numerical scores (ranging from 0 to 5) which were normalized to provide relative weights for each indicator with respect to its main resilience principle. This guarantees that those with mean values that are higher contributed to the composite resilience index as a whole. Therefore, the 52 selected indicators are the most fitting and evidence-based subset for assessing resilience in desert urban settings such as Najaf.

Second: Evaluation and Measurement of the Principle of Economy and Society:

The resilience of Najaf will be measured and evaluated according to the principle of economy and society, as shown in Table 2, by presenting the secondary and sub-goals.

When evaluating and measuring the indicators of the principle of economy and society in Table 2, we find that the goal of supporting the local community and preserving identity ranked first with a percentage of 50%. This was followed by the goal of economy and society in second place with a percentage of 30%. Lastly, the goal of rule of law and security came in third place with a percentage of 20%. Based on the average values of the sub-goals, the analysis of these percentages reveals several weaknesses:

- High local debt and a decline in economic growth.
- There is support for the youth segment, but it is not at the required level to eliminate unemployment.
- Administrative corruption exists in the city.
- There is a weakness in attracting foreign investments.

On the other hand, the strengths are as follows:

- The strong bond among the city's residents and their commitment to their identity are considered major drivers of achieving resilience.
- Empowerment of women in administrative positions.
- There is diversity in the local economy.
- The private sector plays a role, but it does not reach the desired level (Figure 6).

Table 2. Measuring and evaluating the indicators of the Principle of Economy and Society

Score	Value	Indicators	Sub-Goals	Secondary Objectives	Principle of Resilience
2	Low	- Availability of facilities for foreign investment	Providing an Investment-Friendly Environment	Sustainable Economy	Economy and Society
3	Average	- Development plans for the local economy			
2	Low	- Policy to address the housing crisis			
3	Average	- Ease of doing business index	Creating an Effective Work Environment		
3	Average	- Monitoring and oversight of projects			
5	Very good	- The city is characterized by a diverse local economy	Diversity in the Local Economy		
3	882000	- Per capita share of the local GDP			
2	1.4%	- Economic growth rate	Integration with the Global Economy		
2	Low	- Plans to attract global investment			
1	40.8%	- Net debt to GDP ratio	Effective Management		
2	12 years	- Duration of economic asset evaluation periods			
5	Very good	- Public respect for security forces	Effective Security System	Rule of Law and Security	
5	Very good	- Presence of security forces to maintain order			
3	Average	- Crime prevention programs	Implementing Crime Deterrent Systems		
4	Good	- Speed of crime detection			
3	Average	- Level of citizen's sense of justice and equality	Social and Criminal Justice		
3	Average	- Existence of an efficient civil justice system			
3	Average	- Corruption level in the city	Combating Corruption		
3	Average	- Educational and legal programs to combat corruption			
1	2 homes	- Existence of a senior care home in the city	Building Cohesive Communities	Local Community and Preservation of Identity	
4	Good	- Support level for the most vulnerable individuals			
4	43%	- Percentage of women in leadership positions	Supporting the Local Community		
2	Weak	- Support for the youth sector			
2	Weak	- Support for the female demographic			
1	20%	- Percentage of women participating in economic activities			
3	Average	- Contribution level of the private sector in the city	Community Participation		
5	Very good	- Participation in elections			
2	Weak	- Role of community participation in the city	Community Participation		
5	Very good	- Sense of citizenship, belonging and cultural identity	Preserving Cultural Identity		
4	Good	- Existence of festivals held in the city			

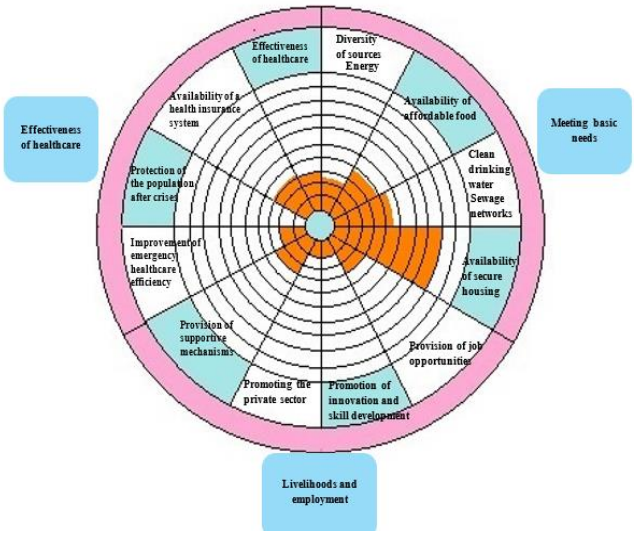

Figure 5. Evaluation of the sub-goals of resilience for the Principle of Quality of Life and Health in the city of Najaf

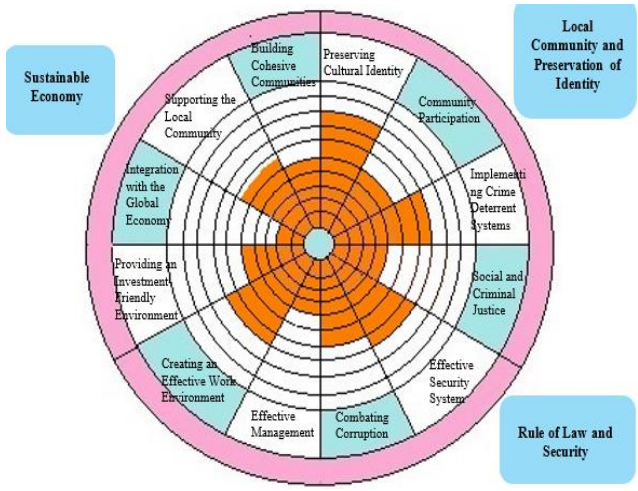

Figure 6. Evaluation of the sub-goals for resilience under the Principle of Economy and Society for the city of Najaf

Third: Measurement and Evaluation of the Principle of Infrastructure and Ecosystems:

In this section, the city of Najaf will be measured and evaluated according to the principle of infrastructure and ecosystems, as shown in Table 3.

From Table 3, we conclude that when evaluating and measuring the resilience of the city of Najaf according to the principle of infrastructure and ecosystems, the averages of the values of the sub-goals indicate that the highest percentage is attributed to the goal of transportation and mobility at 58%. This is followed by the goal of public utilities at 33%, while the goal of risk and crisis management comes in last at 10%.

When analysing these percentages, we find that the weaknesses in this principle are manifested in the following:

- Lack of policies and plans for managing risks and crises.

• The city lacks effective management to protect ecosystems.
• There are no plans to develop and maintain infrastructure networks for sustainability.
• There are no strategies for development in the public services sector.
• Weak roles of local organisations and the private sector in protecting ecosystems.

On the other hand, the strengths in this principle are as follows:

• There is a diversity in the use of transportation means despite the weakness of public transport networks and their maintenance.
• Technology, such as internet checks, is widely used by citizens despite the absence of public internet networks (Figure 7).

Fourth: The Principle of Strategic Leadership and Governance:

In this phase, the resilience of the city of Najaf will be measured and evaluated according to the principle of strategic leadership and governance as outlined in Table 4.

Table 3. Measuring and evaluating the indicators of the principle of infrastructure and ecosystem

Score	Value	Indicators	Sub-Goals	Secondary Objectives	Principle of Resilience
0	None	- Availability of an effective system for operating and maintaining infrastructure.	Availability of resilient infrastructure capable of facing crises.	Crisis and Risk Management Policy	Infrastructure and Environmental Systems
2	9 years	- Time since the last assessment of infrastructure efficiency.			
2	20%	- Percentage of infrastructure networks that meet standards and foundations.	Existence of appropriate standards and foundations.		
0	None	- Existence of an environmental system assessment.	Effectiveness of ecosystem management.		
0	None	- Availability of ecosystem management in the city.			
1	1.5%	- Percentage increase in green areas in the city.			
0	None	- Presence of legislation/plans/policies to protect ecosystems.			
0	15%	- CO2 concentration levels.	Environmental management of ecosystem services.		
1	9 years	- Timeframe for evaluating ecosystem efficiency.			
1	60%	- Percentage of threatened ecosystems in the city.			
0	None	- Role of civic organizations and the private sector in protecting ecosystems.			
1	Very weak	- Availability of maintenance for electricity services.	Resilience of infrastructure.	Availability of Public Services	
0	None	- Diversity in water distribution systems.			
1	Very weak	- Diversity in waste disposal systems.			
1	Very weak	- Availability of maintenance for sewage and water networks.			
1	Very weak	- Presence of future plans for service maintenance.	Sustainability of services.		
1	Very weak	- Availability of future plans for electricity and water distribution networks.	Efficiency of backup service capacity.		
1	Very weak	- Willingness of citizens to donate land for public services.			
4	Good	- Availability of diverse transport networks in the city.	Diversity of transport networks.		
3	40%	- Percentage of public transportation availability in the city.			
3	Average	- Existence of development plans for transport networks.	Maintenance of transport networks.	Transport and Communications	
1	Very weak	- Regular maintenance of transport networks.			
5	100%	- Percentage of internet users.	Availability of communication networks.		
0	None	- Availability of public internet networks.			

Table 4. Measurement and evaluation of the strategic leadership and governance principle index

Score	Value	Indicators	Sub-Goals	Secondary Objectives	Principle of Resilience
2	10 years	- The timeframe for updating city data.	Updating and monitoring city data	Integrated strategic planning	Strategic leadership and governance
1	Very weak	- Is there follow-up on the updated data?			
2	Weak	- Role of stakeholders in planning.	Effectiveness of participatory planning		
2	Weak	- Consideration of stakeholders' opinions.			
3	25%	- Percentage of informal areas in the city.	Proper land-use planning		
2	Weak	- Availability of integrated land-use strategies.			
3	Average	- Presence of laws regulating building patterns.			
2	Weak	- Presenting plans to experts and stakeholders.	Agreement on the planning process		
2	Weak	- Regular updating of data and plans.	Making sound decisions	Leadership and	
2	Weak	- Existence of an urban indicators monitoring process.			

2	Weak	- Coordination between stakeholders and authorities in the planning process.	Coordination between authorities and stakeholders	management effectiveness
2	Weak	- Regular meetings between authorities and stakeholders.		
2	Weak	- Availability of mechanisms/plans to address anticipated risks.	Risk monitoring and evaluation	
2	Weak	- Regular risk assessments.		
2	Weak	- Presence of a risk mitigation strategy.		
3	Average	- Youth participation rate in proposed projects.	Active community participation	
3	Average	- Women's participation rate in community services.		
3	Average	- Role of local organisations in proposed projects.		
5	97%	- Percentage of individuals enrolled in education.	Opportunities for education for all	Empowerment of stakeholders
5	95%	- Percentage of individuals with post-secondary education qualifications.		
2	Weak	- Presence of literacy programs for the elderly.		
2	Weak	- Support provided to emergency service agencies.	Effective crisis management	
2	Weak	- Efficiency in coordinating with international emergency agencies.		
3	Average			
2	Weak	-Social awareness of the population.	Level of social awareness	
2	Weak	- The extent of the role of civil society organizations in raising awareness		

When measuring and evaluating the resilience of the city of Najaf according to the principle of strategic leadership and governance, it is evident from Table 4 that the average values of the indicators indicate that the goal of empowering stakeholders ranks first with a percentage of 49%, followed by the goal of integrated strategic planning at 28%. Meanwhile, the goal of leadership and management effectiveness ranks third at 22%. Upon analysis, we find that the weaknesses in the city according to this principle are as follows:

- There is a lack of effective plans and strategies for managing risks and crises, in addition to a weakness in data updating, which affects the efficiency of administration and leadership.
- The evaluation process for crises and risks occurs at sporadic intervals.
- Relevant parties, particularly emergency agencies are not adequately informed about the final plans, which impacts the effectiveness of integrated strategic planning.
- There is a lack of coordination plans among relevant parties.

Despite these weaknesses, the evaluation highlighted strengths that enhance the prospects for achieving resilience, including:

- There is community participation from youth and women in community services.
- Programs and plans are in place that encourage cultural awareness and increase community participation (Figure 8).

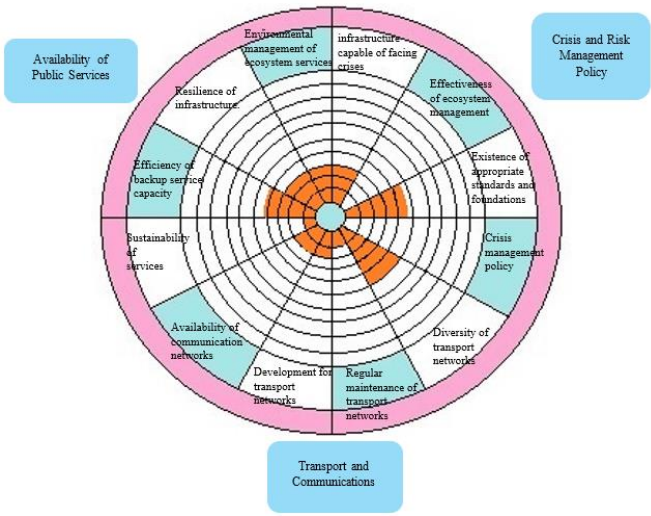

Figure 7. Evaluation of the sub-goals for resilience based on the principle of infrastructure and ecosystems

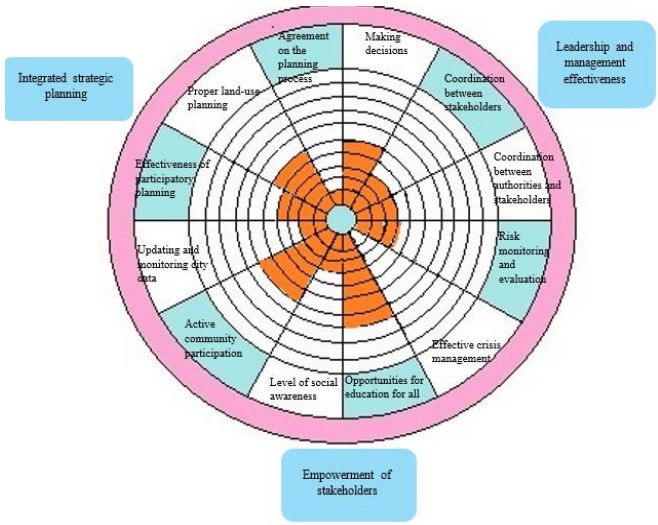

Figure 8. Evaluation of the sub-goals of resilience according to the principle of strategic leadership and governance

3. DISCUSSION

In a desert city facing a lot of both environmental and socio-economic challenges, this study contributes to research on the resilience status of Najaf. Their results reveal that Najaf has some comparative social virtues—cultural identity, healthcare access—but is hugely lacking when it comes to infrastructure sustainability, crisis management, and institutional coordination. These results are in line with earlier research studies done in comparable settings; for example, Sharifi and Yamagata [6] emphasized that governance and infrastructure are the weakest pillars of resilience in developing countries. Najaf's resilience rates in comparison to other desert cities such as Karbala, Buraidah, and Luxor are moderate and could

be substantially augmented by the integration of strategic governance and community participation mechanisms. These results reinforce the CRF model as a diagnostic tool to assist in the detection and study of environmental disaster, whilst also emphasizing the need for local adaptation to desert-specific conditions. That said, there are some limitations that need to be noted. First, the analysis is centered around a single city, which limits the generalizability of the findings. Second, the reliance on expert-based questionnaires, although significant for institutional understanding, may produce subjective scoring. This research should extend to further studies in large numbers of desert cities across Iraq and the Middle East and employ quantitative modeling and scenario-based simulations to evaluate policy interventions and anticipate long-term resilience outcomes. Taken as a whole, the dialogue is a reminder that enhancing Najaf's resilience doesn't just involve a reactive approach to crisis management but rather a more proactive strategic approach that requires renewal of infrastructure, transparency of institutions, and inclusive governance.

3.1 Proposed strategies to enhance the resilience of Najaf as a desert city

The research suggests proactive and comprehensive strategies that focus on social capital, climate, and governance. These strategies can enhance Najaf's resilience to overcome environmental constraints. They include:

1- Climate adaptation through infrastructure development, such as the use of energy and shading systems and heat-resistant materials.

2- Cost-effective adaptation measures.

3- Comprehensive water management that aligns with ecosystems (reuse of treated wastewater and rainwater harvesting). Expanding green spaces and green belts around the city to mitigate the effects of rising temperatures.

4- Diversifying economic resources in a way that complements the city's historical character, such as heritage tourism and religious pilgrimages.

5- Governance and institutional reform, which requires data updating, risk monitoring and assessment, and coordination with various sectors.

4. CONCLUSION

1- The CRF tool is an effective tool for diagnosing the resilience of desert cities at the local indicator level.

2- Najaf's resilience is underpinned by social capital stemming from its historical and religious significance, but it is constrained by governance and risk assessment practices that are generally limited. Decision-makers and urban planners must consider climate-related indicators and establish sustainable integration between governance and long-term planning to determine urban resilience, particularly in desert environments.

3- There are weaknesses in the infrastructure and governance aspects that must be addressed in the city's future development plans.

4- Najaf needs to expand future research that includes indicators for desert cities, especially since it is a city of great religious importance and receives large delegations during Hajj, and to address scenarios that would improve the climate in line with the principles of resilience during long-term urban governance.

5- This study is limited to the case of a single desert city, and there is a need to expand future studies to include comparative studies at the level of several Iraqi cities in order to integrate resilience policies into urban and regional planning at the national level, to understand the reality of those cities, and to identify proactive approaches that can be identified to enhance their resilience.

5. RECOMMENDATIONS

First: Regarding the Principle of Quality of Life and Health:

Based on the diagnosis of the strengths and weaknesses of the Principle of Quality of Life and Health, the research proposes a set of mechanisms to assist decision-makers and relevant stakeholders in enhancing the resilience of this principle in the city of Najaf, including:

1. Developing and rehabilitating informal settlements.
2. Providing healthcare and psychological support to residents to face risks and crises and ensure rapid recovery.
3. Enhancing workforce skills by offering training courses and development programs.
4. Establishing an emergency fund within the city budget.
5. Allocating a percentage of the city budget for marginalised groups and increasing expenditures on improving sewage, electricity and water networks.

Second: Recommendations for the Principle of Economy and Society:

Based on the strengths and weaknesses of the Principle of Economy and Society, some mechanisms have been proposed to enhance the resilience of this principle in the city of Najaf, including:

1. Building a database of urban resources and coordinating local activities and initiatives to address crises.
2. Combating corruption by establishing policies and plans aimed at eradicating it and reducing crime rates.
3. Activating the private sector by providing facilities and the necessary means for its advancement.
4. Adopting policies and strategies to combat unemployment in the city.
5. Creating a financial plan to support economic activities, executive plans and programs to develop household resources.

Third: The Principle of Infrastructure and Environmental Systems:

After assessing the Principle of Infrastructure and Environmental Systems and identifying strengths and weaknesses, mechanisms have been established to improve the resilience of the city of Najaf in this principle, such as:

1. Defining roles for all relevant parties and institutions to face risks.
2. Training and developing detection, monitoring and early warning systems, as well as effective communication systems for all stakeholders, providing them with updated information regarding disasters.
3. Increasing environmental awareness among city residents through programs and cooperation with authorities to preserve the environment.
4. Necessitating the use of renewable energy sources.
5. Training on how to respond to disasters, ensure rapid recovery and reconstruction, and developing plans for the

growth of all sectors in the city to ensure its return to normalcy after a crisis.

Fourth: The Principle of Strategic Leadership and Governance:

Based on the identified strengths and weaknesses, the research proposes several mechanisms to achieve high resilience efficiency for the city of Najaf in this principle, including:

1. Integrating risk reduction strategies with poverty alleviation policies.
2. Increasing the participation of civil and community organisations in disaster risk reduction plans.
3. Encouraging innovations and training and developing skills for both genders.
4. Enhancing institutional capacities to achieve effective management.
5. Properly planning land use and protecting agricultural lands, incorporating them into risk reduction policies, and zoning land according to risk assessments.
6. Updating the city's strategy at least every five years and periodically updating data.

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